

- 11 -

## CLAIMS

1. A method of manufacturing a thin film comprising:
  - a low temperature highly doped layer growing step of performing dopant
  - 5 doping while growing the thin film at a given first temperature;
  - an annealing step of interrupting the growth of the thin film and annealing the thin film at a given second temperature higher than said first temperature; and
  - 10 a high temperature lowly doped layer growing step of growing the thin film at said second temperature.
- 10 2. The method according to Claim 1, wherein a given number of said low temperature highly doped layer growing step, said annealing step and said high temperature lowly doped layer growing step are repeated.
3. A method of manufacturing a thin film comprising:
  - a low temperature highly doped layer growing step of performing dopant
  - 15 doping while growing the thin film at a given first temperature; and
  - an annealing step of interrupting the growth of the thin film and annealing the thin film at a given second temperature higher than said first temperature.
4. The method according to Claim 3, wherein a given number of said low temperature highly doped layer growing step and said annealing step are repeated.
- 20 5. The method according to any one of Claims 1 to 4, wherein a heat-treatment from said first temperature to said second temperature is performed by radiation of a laser beam.
6. A method of manufacturing a p-type zinc oxide thin film comprising:
  - a low temperature highly doped layer growing step of performing nitrogen
  - 25 doping while growing the zinc oxide thin film at a given first temperature;
  - an annealing step of interrupting the growth of the zinc oxide thin film and annealing the zinc oxide thin film at a given second temperature higher than said first temperature; and
  - 30 a high temperature lowly doped layer growing step of growing the zinc oxide thin film at said second temperature.
7. The method according to Claim 6, wherein a given number of said low temperature highly doped layer growing step, said annealing step and said high

- 12 -

8. The method according to Claim 6 or 7, wherein said first temperature is about 300 °C and said second temperature is about 800 °C.
9. The method according to any one of Claims 6 to 8, wherein a heat-treatment from said first temperature to said second temperature is performed by  
5 radiation of a laser beam.
10. A semiconductor device comprising the p-type zinc oxide thin film manufactured by the method according to any one of Claims 6 to 8.
11. The semiconductor device according to Claim 10, said device is a light emitting device.
- 10 12. A semiconductor element comprising:  
a substrate consisting of a material with a lattice constant highly matching that of zinc oxide; a buffer layer of a zinc oxide thin film to which annealed zinc oxide or magnesium oxide is added; and a zinc oxide thin film layer deposited on said buffer layer.
- 15 13. The semiconductor element according to Claim 12, wherein said material comprises any of  $\text{ScAlMgO}_4$ ,  $\text{ScAlZnO}_4$ ,  $\text{ScAlCoO}_4$ ,  $\text{ScAlMnO}_4$ ,  $\text{ScGaZnO}_4$ ,  $\text{ScGaMgO}_4$ ,  $\text{ScAlZn}_3\text{O}_6$ ,  $\text{ScAlZn}_4\text{O}_7$ ,  $\text{ScAlZn}_7\text{O}_{10}$ ,  $\text{ScGaZn}_3\text{O}_6$ ,  $\text{ScGaZn}_5\text{O}_8$ ,  $\text{ScGaZn}_7\text{O}_{10}$ ,  $\text{ScFeZn}_2\text{O}_5$ ,  $\text{ScFeZn}_3\text{O}_6$  or  $\text{ScFeZn}_6\text{O}_9$ .
14. The semiconductor element according to Claim 12 or 13, further  
20 comprising a insulating layer using a material with the same basic structure as that of said substrate.
15. The semiconductor element according to Claim 12, 13 or 14, further comprising a luminescent layer using a material with the same composition or structure as that of said zinc oxide thin film layer as a base, said luminescent  
25 layer being provided on said zinc oxide thin film layer; and a channel semiconductor layer using a material with the same composition or structure as that of said zinc oxide thin film layer as a base, said channel semiconductor layer being provided on said luminescent layer and being different from said zinc oxide thin film layer.
- 30 16. The semiconductor element according to Claim 15, wherein said luminescent layer is any of a multi-layer structure of  $(\text{Mg}, \text{Zn})\text{O}$  and  $\text{ZnO}$ , a multi-layer structure of  $(\text{Zn}, \text{Cd})\text{O}$  and  $\text{ZnO}$ , or a multi-layer structure of  $(\text{Mg},$

- 13 -

17. A method of manufacturing a semiconductor element comprising steps of:
  - forming a substrate from a material with a lattice constant highly matching that of zinc oxide;
  - forming a buffer layer of a zinc oxide layer on said substrate, zinc oxide or magnesium oxide being added to said buffer layer;
  - annealing said buffer layer;
  - forming a zinc oxide thin film layer on said annealed buffer layer.
18. The method according to Claim 17, wherein said material comprises any of ScAlMgO<sub>4</sub>, ScAlZnO<sub>4</sub>, ScAlCoO<sub>4</sub>, ScAlMnO<sub>4</sub>, ScGaZnO<sub>4</sub>, ScGaMgO<sub>4</sub>, ScAlZn<sub>3</sub>O<sub>6</sub>, ScAlZn<sub>4</sub>O<sub>7</sub>, ScAlZn<sub>7</sub>O<sub>10</sub>, ScGaZn<sub>3</sub>O<sub>6</sub>, ScGaZn<sub>5</sub>O<sub>8</sub>, ScGaZn<sub>7</sub>O<sub>10</sub>, ScFeZn<sub>2</sub>O<sub>5</sub>, ScFeZn<sub>3</sub>O<sub>6</sub> or ScFeZn<sub>6</sub>O<sub>9</sub>.
19. The method according to Claim 17 or 18, wherein said buffer layer is annealed at about not less than 1000 °C during said step of annealing said buffer layer.
- 15 20. The method of Claim 17, 18 or 19, wherein said step of annealing said buffer layer is performed in an electric furnace or a deposition apparatus.